

# Factors affecting the viability of smallholders irrigation

## Introduction

The introduction of irrigation into areas where rainfall is insufficient and unreliable and where irrigation is not a traditional practice has been receiving high priority in recent years. It is a trend that will certainly continue.

Generally speaking, however, irrigation schemes in such areas have been found to contribute little to rural development, notwithstanding and often in plain defiance of the original feasibility expectations. Of course, there are exceptions, mainly in the small-scale sector (BALBO 1975). But all too often, sooner or later, after a seemingly successful take-off period, declining yields, diminishing returns, the growing indebtedness of the farmers, and hence their loss of interest, lead to the failure of the schemes. The blame for failure is usually placed on the farmers, but invariably the true cause is an overall lack of viability of the project design itself – a design that did not permit farmers to adopt irrigated cropping as an integral component of a new, self-sustaining, balanced farming system.

The lack of viability of new irrigation schemes is not seldom masked, especially in the large schemes, by a strict, directive, scheme management *ad infinitum* to safeguard national productivity interests. This actually means a curtailment of the farmers' own farm management responsibilities. It reduces them from being participating

producers with family holdings to mere production factors in an estate-type of irrigated agricultural enterprise, of which the survival strategy is based on imposed discipline and centralized execution of essential upstream and downstream farm operations.

*Is that what the introduction of irrigation should lead to? Or can project designs be improved so as to place irrigation in the hands of the farmers, where it belongs?*

In answer to the first question, suffice it to quote BARNETT (1977) who entitled his study of the 2,000,000 acre Gezira Scheme in Sudan – the best-known example of irrigated production under close supervision – 'An Illusion of development'. This terse qualification is, in my opinion, also applicable to other schemes with a similar set-up.

The answer to the second question should be 'Yes', and it could be, provided that development philosophy became farming-system-oriented instead of, what it still largely is, commodity-oriented. It is in this light that – without the pretension of being exhaustive or of presenting concrete solutions for all problems – I shall attempt to review the factors that affect the viability of smallholders' irrigation schemes.

## Farming systems

During the last decades, which were once hoped

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would be a true development era for the Third World countries, development cooperation efforts – and not only in the field of irrigation – have not made their expected impact. General cognizance is growing in recent years, however, that not the farmer is to blame for this, but instead the inadequacy of his institutional environment. Also being recognized is that the promoted technology usually fits neither into the existing farming system nor into the family living patterns. And yet – for lack of knowledge of the existing farming systems – little is being done to bridge that gap. As stated by ENSMINGER (1977), development should be ‘...oriented to helping the farmer *as he is* and not as he may some day become’.

‘Farming system’ is defined here as the whole of activities of a smallholder’s family (‘those who eat from the same kitchen’), undertaken to satisfy their needs. Those activities can be manifold and be either productive or consumptive. They are interrelated or mutually complementary sub-systems of the whole farming system, all drawing from or contributing to the same family resources. How complex a farming system can be is shown by an example, commonly found in the Sudan Zone of West Africa, where one and the same farming system may include the following sub-systems:

**Cropping system 1.**

**Cropping system 2.**

**Cropping system 3.**

**Cropping system 4.**

**Livestock system 1.**

**Livestock system 2.**

**Collecting system 1.**

**Collecting system 2.**

**Off-farm activity 1.**

**Off-farm activity 2.**

**Off-farm activity 3.**

**Consumption system 1.**

**Consumption system 2.**

**Consumption system 3.**

In the world at large, innumerable other farming systems have developed historically. The most important types have been described by ANGLADETTE and DESCHAMPS (1974), DUCKHAM and MASEFIELD (1970), GRIGGS (1974), RUTHENBERG (1976) and JURION and HENRY (1969). As observed by the last-mentioned authors: ‘It is obvious that men have gradually found out by trial and error what forms of production, and in what succession, go best with

Family ‘farms’, under the responsibility of the head of the family, mainly for the production of staple food crops

Cash crop ‘farms’ of individual family members, usually men

Special ‘women’s fields’ for kitchen and local-market crops; the market proceeds are for the women concerned

Home-yard cropping, which – except perhaps for heavy soil preparation work (if applicable) – is usually looked after by the women and the aged family members

Livestock keeping (in areas free of *trypanosomiasis*), with grazing mainly on communal village range grounds, often looked after by young boys

Small livestock and poultry-keeping, in the home-yards

Food gathering and hunting, on communal range grounds

Fishing, in communal waters

Home processing and handicrafts

Petty trading, almost exclusively by women

Seasonal or part-time wage-earning elsewhere; if outside the village, almost exclusively by men

Household and family care (women)

Homestead construction (men)

Social and cultural activities

which ecology’.

The variety of sub-systems, their interdependence, and the relative importance of each sub-system that together make up the overall farming system are determined by the farmer’s setting of resources, constraints, and values. This framework of factors, with the farmer as ultimate ‘decision centre’, is sketched in Figure 1.

All these factors interact, and any one-sided, ‘single-theme’ influence or intervention from out-

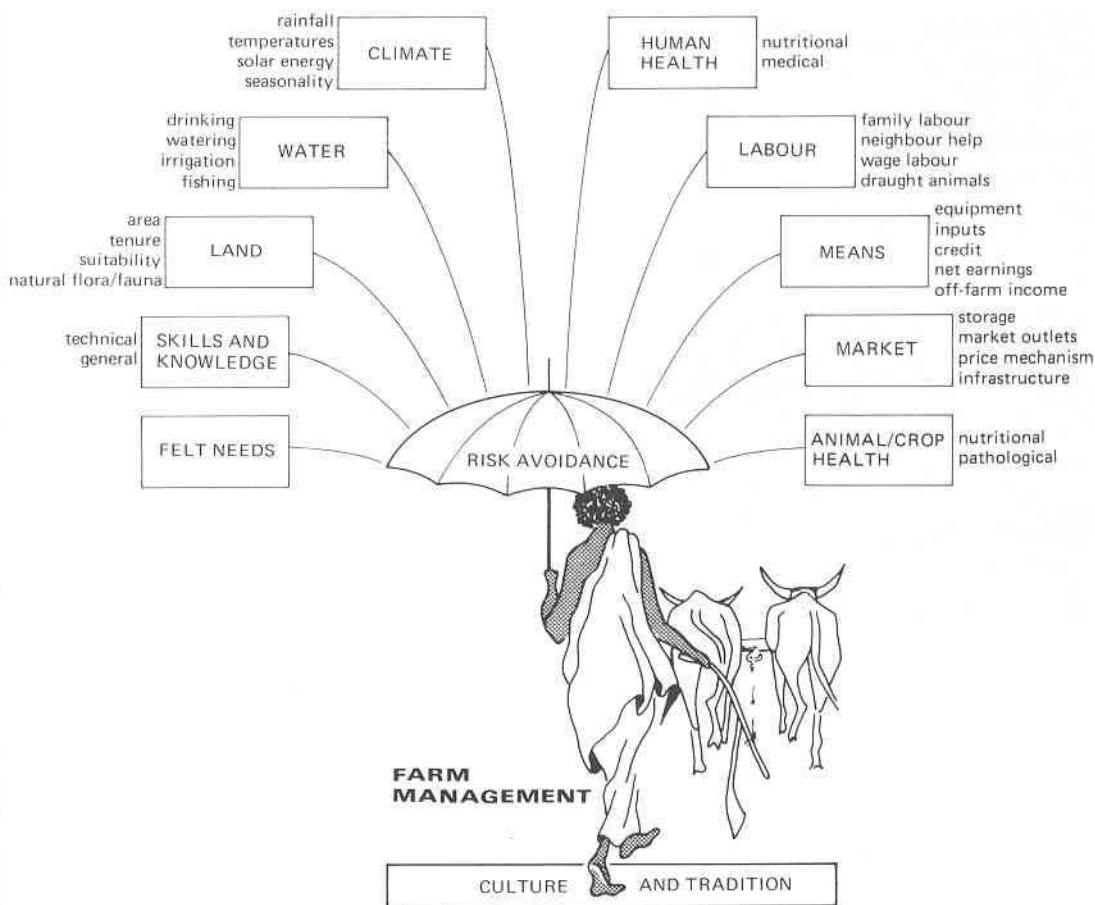


Figure 1.  
The farmer's setting of resources, constraints, and values

crops with diminishing importance are plantains in East Africa, various traditional millet species all over Africa, and the sago palm in South East Asia. Even more radical than the, in fact relatively simple, broadening of an existing cropping system with a single additional crop, is water resource development. Well-known is the example of the ruinous effects that the wildcat construction of watering wells and reservoirs, meant for nomadic livestock improvement, is having in the African Sahel Zone on the land because of overgrazing – and possibly even on the climate, as some scientists believe (OTTERMAN 1977). Water development in the Sahel appears hitherto to have been a rather straightforward case of 'anti-development'. The introduction of irrigation, another form of water resource development, is also a very radical intervention. If conceived only on the basis of agro-technical and economic criteria and without adequate knowledge of all other relevant factors, it bears great risks of upsetting the original farming system rather than improving it. For example, how could irrigation be fitted into the farming system in the Sudan Zone of West Africa? With its specific land and labour requirements, what consequences would a new irrigated cropping system have on the other sub-systems? Would irrigated cropping in the dry season be worthwhile if it would leave the farm family no time for their traditional, typically off-season activities such as fishing, hunting, handicrafts and wage-earning

side, or change from inside (e.g. family expansion), tends to set off a chain-reaction that leaves the farmer with the adaptation problem of how to find a new balance in his farming system. Well-intended interventions sometimes cause a change for the better in the existing farming system – if the innovation happens to relieve a bottle-neck constraint, as when, say, a crop variety with greater drought tolerance and thereby improved yield stability is introduced; but all too often they mean a change for the worse. Re-

gional food problems, for instance, are quite commonly induced by the (macro-economically) successful introduction of cash cropping (LELE 1975). Any success of such single-theme programmes, made possible by the farmers' enticement to cash money, can within a given framework of limited family resources only be achieved at the cost of the traditional crops, usually food crops, in particular the ones with low market values or low unit yields or those that serve mainly as reserve ('security') crops. Examples of such



elsewhere? What consequences would any incompatibility between crops or between entire sub-systems have on the choice of cropping pattern under irrigation and on the farm lay-out? What other crops or activity would need a parallel intensification programme to 'make room' for irrigated cropping? What other programmes are needed to cover those aspects that have a specific bearing on lasting, self-sustained adoption of irrigation? What institutions should be developed simultaneously to support the farmers in their new farming system? All these questions are rarely, or if so, inadequately, taken into account in the design of irrigation projects.

### Discussion of the factors involved

The introduction of irrigation means one of the following:

- a* It converts an existing cropping system, or part of it, into irrigated cropping. Examples are the introduction of irrigation and drainage to eliminate the risks of traditional rain- and flood-dependent rice cultivation in the 'inland swamps' in Sierra Leone, or the same for flood-recession cropping along the Senegal and Niger Rivers.
- b* It adds irrigated cropping as a new sub-system to an existing farming system. An example is the reclamation of swampy wasteland along the

shore of Lake Victoria and the allotment of irrigable plots to neighbouring farmers.

- c* It replaces an entire rain-dependent farming system by an irrigated farming system. Examples are the irrigated (re)settlement projects in areas where rain-fed arable cropping is marginal or not possible, as in the Gezira Scheme in Sudan and the Bura Scheme in Kenya. Farmers will in general encounter fewer adaptation problems under *a* than under *b* and *c*, as *a* constitutes a real improvement in the existing system rather than a change. The constraints to the successful introduction of irrigation – which means an introduction that leads to a lasting, self-sustained adoption of irrigation into new balanced farming systems – are sometimes due to deficient physical and technical planning, as was the case with the Office du Niger in Mali (de WILDE 1967). Usually, how-

(above)

In one photograph, five subsystems of a farming system commonly found in Java, Indonesia:

1. Paddy field cropping of rice with secondary crops, the main production activity of the system (in the photo, between two crop cycles);
2. Livestock keeping. By grazing the rice stubble and the bunds, the water buffaloes keep weed growth under control. Further, they produce organic manure and provide traction power for the heavy work of preparing the land;
3. Duck raising. The ducks keep down the noxious micro-fauna in the paddy fields by feeding on larvae, snails, and so on;
4. Homeyard cropping (in the background), usually with a wide variety of annual and perennial crops in mixed stands to provide the family the whole year round with products for home consumption and petty trading;
5. Household and family care (in the top left-hand corner), one of the consumptive sub-systems. Here, the dehusking of rough paddy.

ever, the true constraints are found among the following factors:

*culture and tradition, felt needs, skills and knowledge, land tenure, land area, land suitability, water, climate, human health, labour, means, market, crop health, risks.*

### **Culture and tradition**

Rain-fed farming is essentially an individual family affair, with traditional forms of cooperation remaining restricted within the family in its widest sense (JURION and HENRY 1969). But irrigated farming is typically a community affair. In smallholders' farming it would indeed be an absurdity for each family to have its own intake works and supply canals, although such inefficient situations do exist. In the western coastal plains of Madagascar, for instance, temporary transmigrants, originating from different village communities in the overpopulated highlands, run individually-irrigated rice farms for the duration of their working life – without seeking cooperation with their neighbours. Development efforts to reorganize the water distribution did not meet any particular problems once the farmers had agreed that ancestral rivalry between their native villages did not necessarily preclude the possibility of applying the traditional form of effective communal water management – which they all knew very well from their native villages.

Farmers who depend on the same irrigation sys-

tem have to adopt a strict group discipline in cropping pattern (different crops have different irrigation and drainage requirements), farm operations calendar, water use, and canal maintenance. The necessary communal sense must be built up, utilizing whatever useful forms of traditional cooperative village structures there may be. Regular farm maintenance is in itself a novelty, entirely alien to the old rain-dependent system in which a new piece of land was opened up whenever the old land was no longer arable (mainly) because of weed accumulation. Even now, in areas where shifting cultivation is no longer possible because of the shortage of land, maintenance is a difficult development theme, whether it concerns keeping the fields clean of noxious weeds, the seasonal reshaping of bunds and field ditches, or the regular repair of the homestead. Indicative of the viability prospects of smallholders' irrigation is the active involvement of the beneficiary farmers in the construction of the irrigation works, including its work organization (BALBO 1975). Such 'human investment' in communal labour fosters group responsibility for the work accomplished, a prerequisite to motivating villagers to take part in the operation and maintenance of 'their' scheme.

Another strategy, sometimes advocated by planners as an easier and more efficient alternative, consists of getting all the construction work down to farm level done by contractors and – to make

the farmers as yet feel that the scheme is theirs – by 'selling' the irrigation facilities to them afterwards through a long-term repayment contract. This strategy, however, cannot be but a faulty one: firstly, it saddles farmers with a heavy debt burden which is a poor start anyway; secondly, it does not stimulate the necessary group spirit as the farmers remain individual debtors; and, thirdly, it does not create the feeling that the scheme becomes 'theirs' as farmers normally regard such long-term financial obligations as just another government tax that skims the cream off their income (the factor means).

Active involvement of the farmers as from the planning stage, properly guided by purposive community development programmes, also creates the foundations for sound grassroot farmers' cooperatives, which should be able to look after the farmers' own interests – unlike the conventional 'cooperative' that is normally little else than a village-level tentacle of a neo-colonial marketing organization.

Furthermore, because of the usually high investment costs involved, irrigation planners have to work under the pressure of economic criteria. This invariably leads to simple farm lay-outs with concentration on cash crop production. Applied to the traditional farming system of the West African Sudan Zone, the irrigation scheme would take the place of cropping system 2, the cash crop 'farms' of individual villagers, mostly men. It

is obvious that such a biased point of departure already encourages further individualism rather than building up the necessary community responsibility.

### Felt needs

Irrigation schemes that represent the one-sided improvement or addition of one single sub-system entail almost automatically an unfair competition with the traditional family sub-systems outside the scheme. Western thinking in terms of purely economic maximization criteria tends to ignore the value of those other sub-systems even if they are an essential part of the people's living pattern. The pressure of short-term economic feasibility leaves no space in rural development design for such family and community needs as the inclusion of 'minor' subsistence crops, easily cultivable 'old people's' crops, special 'women's fields', livestock as an integrated part of the system, production opportunity for petty trading, crops that are suitable for small-scale processing industries to provide off-farm employment, and last but not least the ownership of the land. Yet, compliance with such felt needs – which largely find their roots in culture and tradition and are important in minimizing the factor risks – might greatly contribute to the balance, hence the viability, of the new farming system, even if seemingly irrational or affecting the project's internal rate of return. It would also positively

influence the people's willingness to participate in the construction and functioning of the irrigation scheme.

The basic issue therefore is whether development agencies attach more importance to long-term than to short-term project results and are prepared to set project-appraisal criteria accordingly. If so, they will consider not only the factors water, land, and climate but, in choosing the cropping pattern, they will also consider the farmers' felt needs, the labour required for the crops, and the long-term cost returns expectations (the factor means). On this basis they will decide which compromise solution is preferable: a farming-system development project with irrigated as well as rain-fed cropping and other sub-programmes, or solely an irrigation project but then designed for a widely diversified cropping pattern which requires, undoubtedly, a more complicated

scheme lay-out.

The latter option is virtually a must in semi-arid and arid areas where non-irrigated cropping is too marginal or not possible at all. There, because of the different requirements placed on irrigation and drainage by different crops, each holding should have as many plots as it will have crops or crop mixtures and fallows (if these are necessary) in any one season, with each plot located in a different irrigation unit ('quaternary unit'). This has direct consequences for the size and shape of the tertiary and quaternary units and for the size and location of the villages, because the distances between the plots of a single holding as well as between the fields and the village should be as short as possible.

### Skills and knowledge

In areas where irrigation is not a traditional prac-



Farmers do not like to depend on cash crop production alone, in their irrigated plot they want to grow food crops as well. Here, 'illegal' maize and beans (in the foreground of the photo) in an irrigation scheme in Kenya.

tice, people do not know how to operate the water supply, how to dose the quantities of water, what the specific crop requirements are for both irrigation and drainage, how to prepare the land, or how to repair bunds and canals. They do not realize the dangers of water-borne diseases or the effects of agro-chemical pollution on human health. They do not know how to avoid erosion and salinization of the land. They are ignorant of the effect on crop health of prolonged waterlogging, insufficient weed control on bunds and road sides, and the overlapping of standing crops that cause the accumulation over the years of pests and diseases, a very common cause of declining yields. This all calls for intensive farmer training (Extension) even more highly geared than that required for the introduction of a new crop in rain-fed farming. At least during the take-off phase of the scheme, this training should be guided by operational extension research to develop locally adapted extension methods and explore particular adoption problems.

Intensive farmer training, however, will remain an academic proposition only, unless qualified local staff is available to do it. Here, we touch upon a basic problem of the Third World countries; and the shortage of qualified staff specialized in irrigation is particularly pronounced. In most countries where irrigation is a novelty, the formal educational facilities to specialize in irrigation do not even exist. The system of strict management con-

trol in many of the larger irrigation schemes has without doubt been the answer to the problem of how to realize high investment returns within a short time and with an absolute minimum of staff qualified in irrigation matters. The question then remains: what is being done to improve the man-power situation in those countries where, from senior staff down to farmer level, skills and knowledge are apparently the major constraint for irrigation ever to become an integral part of a balanced smallholders' farming system?

In fact, very little is being done. 'Counterpart' training, although stipulated in almost every project plan of operation, has proved to be a myth. And badly needed development efforts to assist local universities and lower training institutions in setting up formal irrigation courses are rare. If national and donor development agencies could agree that 'development primarily concerns *people*', and also agreed that 'development will result from a build-up of people's knowledge of their natural environment and its possibilities', they would give man-power training the highest priority in development cooperation. The results of irrigation projects would then not primarily be evaluated, as now, on the basis of short-term production successes – which has proved in practice to be an '*après nous le déluge*' approach, leaving the host country with the problems of follow-up and continuity – but on the basis of the number and competence of staff trained by

the projects and of actual community performance by the farmers.

Irrigation projects should be designed accordingly, with emphasis on the training component. In-service training should have a systematic, organized character, geared to produce several qualified nationals per (only temporarily assigned) 'expert' – several, to allow for drop-outs and yet permit project expansion. In view of the increasing staff requirements in the future, the project plan should also include that project staff lecture part-time at existing training institutions, that they supervise and guide temporary project-based students, organize courses for non-project personnel, and conduct workshops for senior staff of relevant government services, universities, and research stations.

#### **Land tenure**

Often forming a serious constraint to irrigation development are the old land ownership or traditional land use rights. These should be studied and the solutions definitively accepted by all parties concerned prior to project implementation. Otherwise, problems may arise from people harassing scheme farmers, under the pretext of having older land use rights; or, especially in riverain areas, which were of old the dry-season grazing grounds of pastoralists and have since been reclaimed and converted into irrigated land, from transhumance livestock herds that season-

ally inflict damage to crops and irrigation infrastructure. As disciplinary measures to keep the pastoralists out may seriously upset their traditional livestock system, the only acceptable solution in this case would be to consider the introduction of irrigated agriculture in a broader context of 'area development', with two parallel but interrelated development programmes, one for irrigation development and the other for livestock intensification.

Another problem related to land tenure is that irrigated cropping implies permanent land use. This has consequences for the most desirable tenure status of the scheme farmers because permanent and intensive land use requires regular investment (allocation of means) on the part of the cultivator. The necessary motivation to invest, however, is certainly not fostered by the common practice in large irrigation schemes of granting to scheme farmers the permanent status of *tenants* only. Scheme farmers should have a title-deed to their irrigated plots, provided, of course, that strict regulations protect them from the dangers of mortgaging their land to money-lenders and middle-men once the irrigated land has become a marketable property.

#### **Land area**

The total area of irrigated land to be allocated to each holding is usually decided on the basis of the estimated labour requirements of the crops

that are to be grown in the scheme. No consideration, or only very little, is given to the labour required for other family activities or to the quite conceivable possibility of having to grow other crops because of market or other constraints. Moreover, labour requirements are often underestimated. For instance, rice transplanting in most African rice schemes turns out to require about twice as much labour as it does in Indonesia. If the labour-requirement calendars of the various sub-systems prove to be incompatible, the farmer will be forced to neglect one or more of the sub-systems. Depending on what activity responds best to his felt needs, he will not infrequently neglect his irrigated crop(s); the result is yields below expectation – as happened, for instance, in the rice schemes in Western Kenya that were added to an existing farming system with year-round activities. Sometimes the off-scheme activities tend to be neglected – thereby increasing the farmers' risks – as happened, for instance, in the otherwise successful village rice schemes along the Senegal River.

If the planners had had a thorough knowledge of the existing farming system in all its facets, if they had made a less generous allocation of irrigated land per holding, and had instituted a polyvalent action programme, a more balanced development would probably have resulted. In the Western Kenya rice schemes, where four-acre plots were allocated to surrounding farmers, smaller plots of,

say, half an acre or one acre each would not only have enabled farmers to devote more care to the crop and thus obtain higher yields, but it would also have given four to eight times as many poor families in the area the opportunity of improving their income.

#### **Land suitability**

In its cropping potential and possibilities for irrigation, land suitability is not a fixed qualification. It is subject to change when the land is used for agricultural production (MOORMANN and van BREEMEN 1978). For instance, soils that were once classified as permeable and therefore less suited for wet-rice production may lose their permeability after some years of cultivation and become good padisoils but less suitable for the originally planned 'dry-foot' crops. Or soils may lose their originally assessed fertility level – the basis of the feasibility expectations – because of the high export of soil nutrients and the incomplete replenishment by a one-sided fertilizer that was once considered adequate. Other changes in soil characteristics may be due to salinization or to wind or water erosion of the topsoil. All those changes in land suitability, with the risk of reaching the point of no return, can be put down not only to inadequate input of labour and means, but also, if not in the first place, to insufficient knowledge of the appropriate agricultural practices. Intensive land use, made possible by irrigation,



Ancient method of lifting water for the irrigation of thirsty land in the Augila Oasis in Libya. A simple, modern improvement was to line the conveyance ditches with plastic to reduce the water losses in the sandy soils, thereby greatly shortening the time required for the twice-daily watering of the tiny plots of wheat and tomatoes. Note the screens of date palm leaves along the tow path to protect man and mule from the blazing sun.



asphyxiation.

Gradual yield decline due to insufficient water control is often caused by too tight a cropping pattern, which leaves no time for the periodic drying of the soil. Prolonged waterlogging leads to severe soil reduction, which – depending on soil type, pH, organic matter content, and other soil characteristics – promotes a range of physiological diseases and thus affects crop health. Some of these diseases are known to be related to an excess of soluble ferrous iron, sulfides, or organic acids, or to a lack of zinc (MOORMANN and van BREEMEN 1978).

Insufficient drainage and/or under-irrigation may also cause a gradual salinization of the soil, with a resultant decline in land suitability. A classic example is the deterioration of ancient irrigated agriculture in the Middle East.

### Climate

The climate is one of the decisive factors in the planning stage of an irrigation scheme, affecting, as it does, the scale of suitable crops and the design of the irrigation and drainage network. Once the scheme is there, however, a true climate constraint is the irregularity of the rainfall pattern. An irregular rainfall pattern makes it difficult to ensure the proper control of water, especially in large irrigation schemes with poor communications between the tertiary unit and the main and secondary water-intake works. In such schemes,

it frequently happens, during the usually very erratic rainy seasons, that large quantities of expensive irrigation water are wasted or, if kept on the fields, cause flooding and subsequent crop damage.

This problem could largely be overcome by setting up a warning system to report the mostly very local rainstorms to the operators of the intake works. The farmers themselves could play a major role; grouped per tertiary unit, they could elect a 'water guard' who, after appropriate training, would assume responsibility for immediate rainstorm reporting and for the operation of the tertiary water-intake and drainage gates. This water guard should be a 'community official' and

should be accompanied by on-farm research of the 'monitoring' type to keep the scheme management knowledgeable of the processes of change set going by the development intervention. Soil monitoring, unfortunately, is seldom done in practice, although it can be a relatively simple matter: selected farmers can be trained to do regular soil sampling and/or cooperate in conducting observation plots. Monitoring should be part of a routine after-care of the project, to enable scheme management and extension workers to take timely corrective measures and to adapt the extension themes whenever necessary.

### Water

Poor irrigation and drainage are a very common cause of disappointing crop yields. The basic problems may lie in the factor skills and knowledge (also on scheme level) and in the attitude towards maintenance (culture and tradition). But it is no exception either that a drainage network is simply excluded from the scheme lay-out because of considerations of keeping the investment costs low: an economic short-sightedness that leaves the farmers and the host country in the lurch after some years of cultivation.

Poor irrigation and drainage may also be due to poor land preparation, especially levelling, resulting in spots with water shortage, which encourages noxious weed growth, and spots with excess water, which hampers tillering or causes

should receive from his farmers' group an incentive in the form of a nominal monthly fee, perhaps partly in cash and partly in kind.

### Human health

The factor human health deserves special mention because the introduction of irrigation into an area may thoroughly upset the local parasitic ecosystems and, by so doing, cause an explosive development of water-borne diseases. Particularly notorious are river blindness, whose vector, the *Simulium* fly, breeds in running water, and the diseases whose vectors breed in standing water: malaria (transmitted by *Anopheles* mosquitoes), and bilharziasis (spread via *Bulenus* snails). These and other (e.g. intestinal) diseases seriously affect people's health, and hence their labour, and by that jeopardize yields and income (the factor means).

Any plan to introduce irrigation should therefore include: in-depth inventorization of indigenous diseases and their vectors, and in the case of resettlement projects the same in the areas of settlers' origin, to be followed by regular vector control campaigns and preventive routine health care.

LUCASSE (1976) suggests that traditional healing arts be given new impulses for development by integration with simple western methods, and that local medicine should play an important role in routine health care after the phasing-out

of the project.

Adverse effects on labour and ultimately on means are also caused by seasonal food shortages or chronic malnutrition. One-sided project orientation to develop cash crop production cannot but aggravate, if not induce, such problems.

### Labour

The various smallholder activities all draw from the same farm family labour resources, supplemented for certain farm operations by neighbour help, casual wage-labour, and animal power. The introduction of irrigation will necessitate an important shift in the traditional allocation of labour because of the specific labour requirements of irrigated farming. These concern not only a more intensive level of crop cultivation to make optimum use of the high production potential offered by the irrigation facilities, but also concern community constraints of a strict farm operations calendar and of the additional communal work load required for the regular maintenance of bunds and canals. The community aspects have already been mentioned under culture and tradition, the competition for labour between the different sub-systems under land area per holding, and the influence of health and nutrition on working ability under human health. Working motivation on the other hand is mainly a question of priority ranking of felt needs and of the expected return on efforts (the factor means).

The many unknowns that determine farmers' behaviour as to labour allocation, ability, and motivation – which, moreover, will differ from project to project – cannot be solved during a project's planning phase. They therefore require a flexible project design with an important socio-economic research component of the monitoring type. This will permit timely programme modification, adjustment of the cropping pattern, or any other improvement measure, according as research data become available.

### Means

Development is usually measured on the basis of estimated net income, a rather dubious criterion as is illustrated by the Gezira Scheme, where the situation of the farmers does not reflect the Scheme's reputation of success: 'Those farmers who are solely dependent on their tenancy (the majority of the tenants) are in a situation of constant indebtedness and shortage of cash' (BARNETT 1979).

This is, in fact, a very common situation – found in many production intensification projects and not only in irrigation schemes. Causes may be manifold, their main points differing according to project type and to natural, cultural, and institutional conditions. Many of them, however, share the following shortcomings:

- Farmers are not credit-minded, in the sense that they do not fully realize the consequences of a

debt burden; they tend to take up credit rather in- judiciously; for instance, they expend their means to hire labour or tractor services for work that could well be managed by themselves and their family, or to buy luxury goods and foods. This can be explained by influences from the environ- ment (induced felt needs) and ignorance (the factor knowledge). Credit should be a principal extension theme in development work, which in practice it seldom is

- Reliable credit facilities are inadequate, either in volume or in flexibility or are meant (the usual case) for a single cash crop only, which drives farmers into the hands of profiteering money- lenders. Credit facilities should be developed to cover the requirements of the farming system as a whole. Part of the credit, e.g. for consumptive use, might better become a community responsi- bility ('Village Funds')

- The farming system is not balanced. Farmers are not self-reliant in food production, because of too narrow a cropping pattern imposed on them by scheme regulations; they are obliged to pur- chase their food for much higher prices than it would cost them in home-production. Especially in the months prior to food crop harvest, market prices for foodstuffs may reach exorbitant levels, which are not reckoned with in the original net income estimates

- Market outlets or prices for the cash crops are not guaranteed, as will be discussed in the next section.

### Market

The construction of an irrigation scheme, with its high production potential, within a region that otherwise remains dependent on the whims of natural rainfall, may cause the collapse of the lo- cal markets for the irrigated commodity and wipe out its traditional producers outside the scheme. Examples can be found in West Africa (irrigated vegetable production) and India (isolated irri- gated rice schemes).

Irrigation schemes should therefore be part of a regional development plan, with parallel deve- lopment programmes and appropriate market- protection measures for the farming communities outside the schemes. Programmes inside and outside the scheme should complement one another.

Examples exist also of irrigation schemes where the obligatory market crops do not find a guaran- teed post-harvest outlet when needed; for in- stance, outgrowers' sugarcane that has to wait until the nucleus estate's production has entered the processing line. Examples are also known of the (again) obligatory cash crops being subject to strong and irregular price fluctuations because of unpredictable production levels elsewhere.

In such cases, the risks of market production are shifted entirely onto the shoulders of the intend- ed scheme 'beneficiaries', who have no reserves to make up for even occasional losses. Firm mar- keting guarantees, flexibility in the cropping pat-

tern, and the build-up of farmers' cooperatives, able to protect individual and group interests, form the essential pre-conditions for irrigated cash crop production.

Finally, certain market aspects such as price ratios between inputs and expected outputs and the reliability of timely input supplies are so well known that they need no special discussion. Suffice it to say that they exert a predominant influence on farmers' motivation and, ultimately, on farmers' income (means).

### Crop health

Necessary for sound crop yields, crop health, in respect to both its nutritional status and freedom from pests and diseases, is the combined result of various factors that have already been discussed: skills and knowledge of correct agricultural prac- tices, land suitability, proper water control, cli- mate, sufficient and timely labour inputs, and the necessary expenditure of means for adequate crop protection and plant nutrition.

These very factors, however, give rise to as many constraints—constraints that are difficult to con- trol, especially for the small farmer. The growing awareness of this fact and the increasing concern on national and international levels about the problems that small farmers face in adopting mod- ern technology, has in recent years led to a re- orientation of research towards new technology that fits better within the framework of possibil-

Mixed cropping— here in a homeyard in the Selva Zone of Peru— has many advantages: it makes optimum use of (limited) land, water, and light; it saves labour, keeps down pests and diseases, protects the soil by a permanent vegetative cover; and last but not least, because of the variety of crops grown throughout the year, it provides the

ities of the small farmer 'as he is'.

Especially in areas where irrigation is not traditional, for instance, the variety choice of the irrigated crops should be based rather on considerations of obtaining satisfactory but stable yields even under adverse conditions than on high-tuned expectations of super yields that require perfect growing conditions and high input levels. In a later project phase, more exacting extension themes, including the use of modern varieties and increased input levels, can always be introduced when farmers have reached the necessary farm management level to adopt such themes profitably.

### Risks

It is probably their strategy of risk-avoidance that characterizes all small farmers. The world over and whether commercialized or not, traditional farming systems have evolved which have given proof of real viability— something that obviously cannot yet be said about the modern, (meant to be ) improved farming systems designed *for* small farmers (but *without* them) during the last decades of development cooperation efforts. Although irrigated crop production in itself is less risky than rain-fed farming— and is the reason why farmers normally show great interest in irrigation— the very dependent status of the tenant-farmers *vis-à-vis* the scheme management with regard to water supply and, in many schemes,

farmer with some degree of protection from the risks of individual crop failures.

Western prejudice against mixed cropping, because of the difficulties it poses for mechanization, was the reason why the possible improvement of this cultivation method was so long neglected by researchers.

also the timely arrival of machinery and inputs, implies great risks for them.

Just imagine what would happen if, in an isolated irrigation scheme with a narrow alternating cropping system of cotton followed by maize (the planned cropping system for the Bura Scheme, Kenya), water supplies were to break down during maize flowering and this sole food crop fails. The result would be soaring market prices for foodstuffs and indebtedness of the tenants to money-lenders and middle-men.

Also the farmers' dependence on one single cash crop, which gives them a bulk cash income once a year, bears great risks for them: either because of possible crop failure or— a very common thing— because of injudicious spending after pay-out due to ignorance (the factor knowledge) and the appeal of western luxury goods (the factor felt needs) induced by commercial pushing ('Guinness is Good for You!') through uncontrolled market interference.

Diversity of production sub-systems as well as of crops within cropping systems has always been a very effective way of reducing risks in traditional farming systems (UPTON 1973). It appears that diversification also remains the best solution for low-risk irrigation development. To this should be added the important agronomic consideration that crop diversification and a judiciously designed crop rotation permit optimum utilization of family labour resources throughout the year, and



are, of old, the cheapest way of maintaining soil fertility.

### Conclusions

Within the sphere of salient factors discussed above, the farmer is expected to take his best farm management decisions. To state that the introduction of irrigation is complicated and involves more than merely digging canals and deducting the costs from crop proceeds is obviously forcing an open door. But the question remains: what development strategy should be adopted to assist farmers to integrate irrigation into a new balanced farming system? Fundamen-

tal for such a strategy will be:

- To place basic farm management responsibilities in the hands of the farmers themselves. There is no indication whatsoever in the history of development intervention that a take-over of those responsibilities by outsiders can result in lasting, self-sustaining agricultural development. The role of scheme management should be restricted to guiding the farmers in their technological and socio-economic development process, providing services and technical facilities on the basis of a policy of decreasing scheme management decision and maximum delegation, thereby evoking among the farmers the maximum of initiative and responsibility. The farmers' way of life, their group identity and personal dignity are the only legitimate objects of development efforts (BUNTING ed. 1970)
- To adapt project design and technology to the farmers' needs and possibilities, building on the basis of the existing farming system. This requires a thorough study of the local farming system and all its sub-systems, to be followed during project implementation by 'Farming Systems Development Research' (CGIAR 1978). Essential in this type of research are on-farm testing and monitoring
- To plan project programmes according to *constraints priority*, so as to make the project design no more complicated than need be. This requires flexibility in the original project design. It also

requires, as a component of the farming system research, 'constraints research' of the type developed by the International Rice Research Institute, Los Baños, Philippines (DE DATTA et al. 1978)

- To involve the intended beneficiary farmers in scheme affairs as from the planning stage, promoting community work and the formation of farmers' associations based on communal interests, and training them from the very beginning to gradually take over the responsibilities of tertiary unit (or village scheme) operation and maintenance
  - To assure, within a regional development context, the build-up of, and communication between, farmers' associations, research, extension, input supply, credit, a fair and stable market and other services. Appropriate in-service as well as formal training is a prerequisite for such 'institution-building', which should be an essential element in any irrigation development plan.
- These five principles should be pursued simultaneously. This has several consequences for development policy-making, first and foremost of which is a reconsideration of current technological project appraisal criteria that have proved to be of little relevance for the long-term viability of irrigation schemes. Secondly, the complexity of irrigation development demands a programmatic, well-coordinated, multi-sector approach, beginning on a modest scale ('starter

projects'), so as to allow a satisfactory fanning-out of the programme as knowledge, experience, and qualified local man-power are generated. Thirdly, the complexity of irrigation development also requires that donor agencies abstain from individual, non-integrated (and in fact mere flag-showing) irrigated-production projects, but rather pool resources to enable the host country to build up its own abilities to implement the necessary long-term multi-sector programmes.

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